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HARDNESS VERIFICATION OF ANTENNA LINE PENETRATIONS

STANDARDS AND TECHNOLOGY INTEGRATION MEETING,

Sanitized Version

21 SEPTEMBER 1994

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"Test Techniques for Antenna Line Penetrations," 23 May 1994, MRC/COS-R-1394
[redacted]t, 8/22-9/1/94 - Quick Look Data

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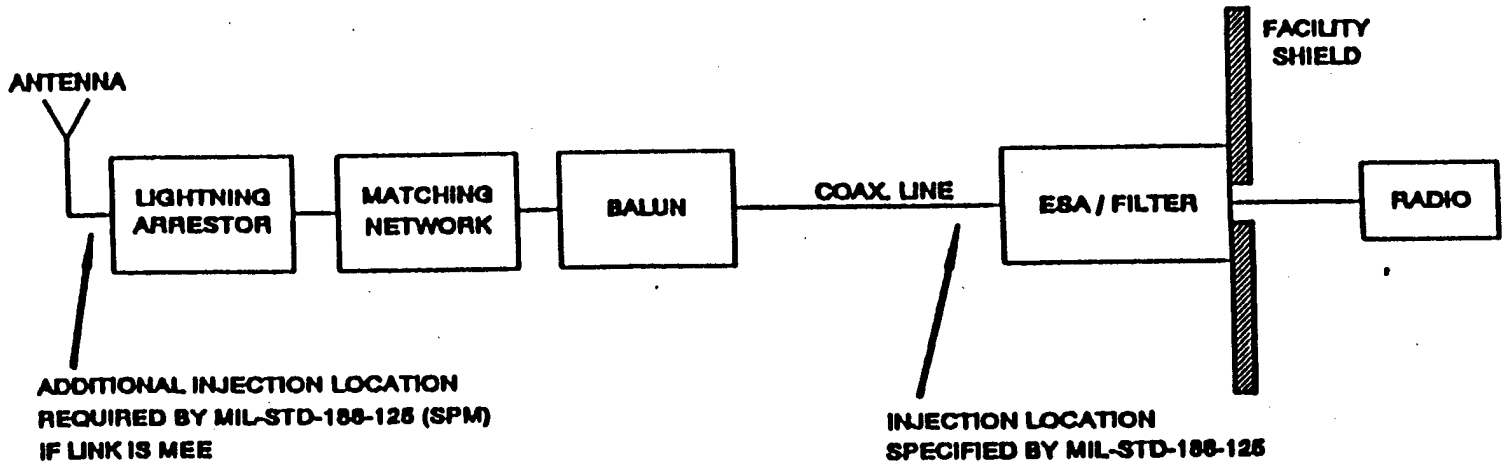
TYPICAL HEMP COUPLING PATH FOR ANTENNA LINES



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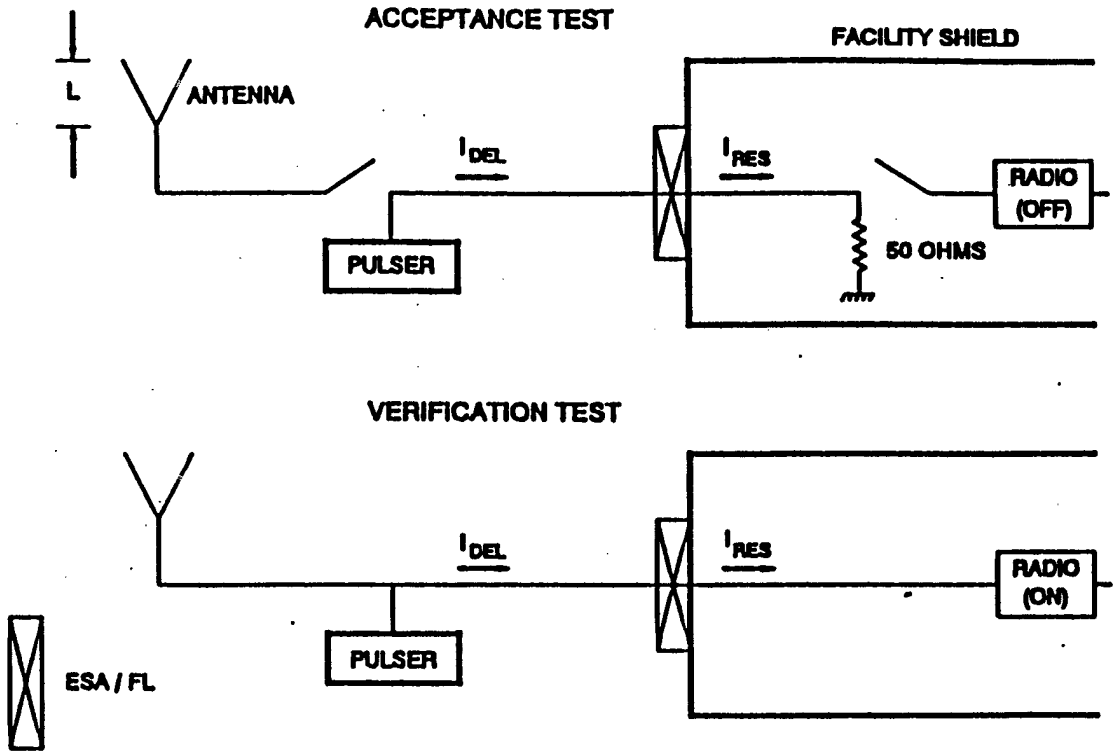
PROCEDURES REQUIRED BY MIL-STD-188-125

1. The test waveform is a damped sinusoid (Q=10±3) with peak amplitude and fundamental frequency determined from the maximum linear dimension (L) of the antenna radiating structure by the algorithm:

If	300 m >	L > 20 m,	then f_c= 2 MHz,	I_{pk}=2500 A;
if	20 m >	L > 3 m,	then f_c= 30 MHz,	I_{pk}=900 A;
if		L < 3 m,	then f_c=200 MHz,	I_{pk}=250 A.

2. The injections must be performed in the acceptance test and verification test configurations.


ACCEPTANCE TEST
FACILITY SHIELD
L
ANTENNA
I_{DEL}
I_{RES}
RADIO (OFF)
PULSER
50 OHMS
VERIFICATION TEST
I_{DEL}
I_{RES}
RADIO (ON)
PULSER
ESA / FL

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- Difficulties with implementation of MIL-STD-188-125 requirements
  - No such pulsers available
  - Test waveforms often do not represent HEMP stresses (test waveform may be inadequate in some cases)
  - Acceptance test pass/fail criteria usually cannot be met

  → Most antenna line penetrations will be SPMs

- 5-step procedure proposed to test antenna lines as SPMs
- Lab and field tests to demonstrate proposed procedure

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PROPOSED TEST PROCEDURE

STEP 1: VERIFY PROT. EQUIPMENT IS WORKING PER SPECIFICATIONS (CWDD of FL, voltage step fcn test of ESA)

STEP 2: DECIDE PCI LOCATION

STEP 3: ESTIMATE LINEAR HEMP STRESS (Wide-area CWIL, local CWIL, other)

STEP 4: SELECT PULSER(s), INJECT, AND ESTIMATE TEST COVERAGE

$$\max I_{RES}^{HEMP} \; vs. \; \max I_{RES}^{PCI}$$

$$\max I_{DEL}^{HEMP} \; vs. \; \max I_{DEL}^{PCI}$$

- HEMP vs. pulse induced outage time (if link is MEE)

STEP 5: REPEAT STEP 1

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EVALUATION OF TEST COVERAGE (ACCEPTANCE TEST CONFIGURATION)

	BELOW ESA BREAKDOWN					ABOVE ESA BREAKDOWN				
	MAX I_{DEL}		MAX I_{RES} (e)		IS TEST COVERAGE ADEQUATE	MAX I_{DEL} (a)		OUTAGE	MAX I_{RES}	IS TEST COVERAGE ADEQUATE
	Peak (A)	RAINT (A-s.5)	Peak (A)	RAINT (A-s.5)		Peak (A)	RAINT (A-s.5)	Time (ns)	Peak (A)	
HEMP on [redacted]	6.40E1	2.50E-2	5.60E1	2.48E-2	n.a.	2.37E3	9.86E-1	500	(c)	n.a.
E1 Pulser	5.00E1	3.18E-2	1.65E1	4.30E-3	Maybe	2.50E3	1.68E0	1000	1.75E1	Yes
2MHz DS per MIL-STD-188-125	4.00E1	2.52E-2	2.80E0	8.42E-4	No	2.50E3	1.58E0	>1000	(c)	Yes

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[redacted] TEST OBJECTIVES

1. Implement/demonstrate the proposed test procedures

2. Evaluate the test coverage achieved with charged line pulser

3. Determine feasibility of local CW illumination to estimate HEMP stresses

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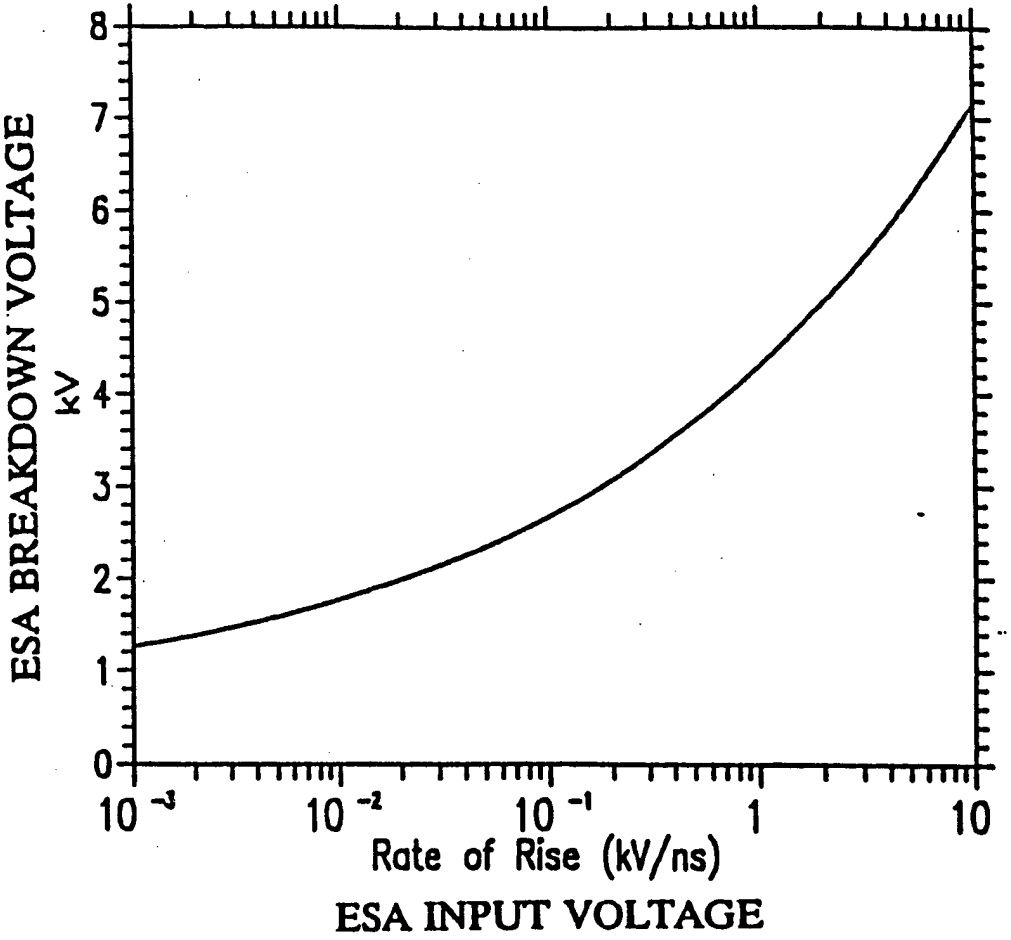
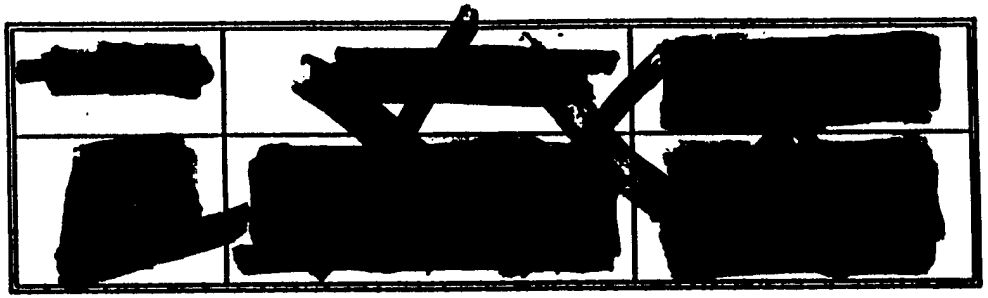
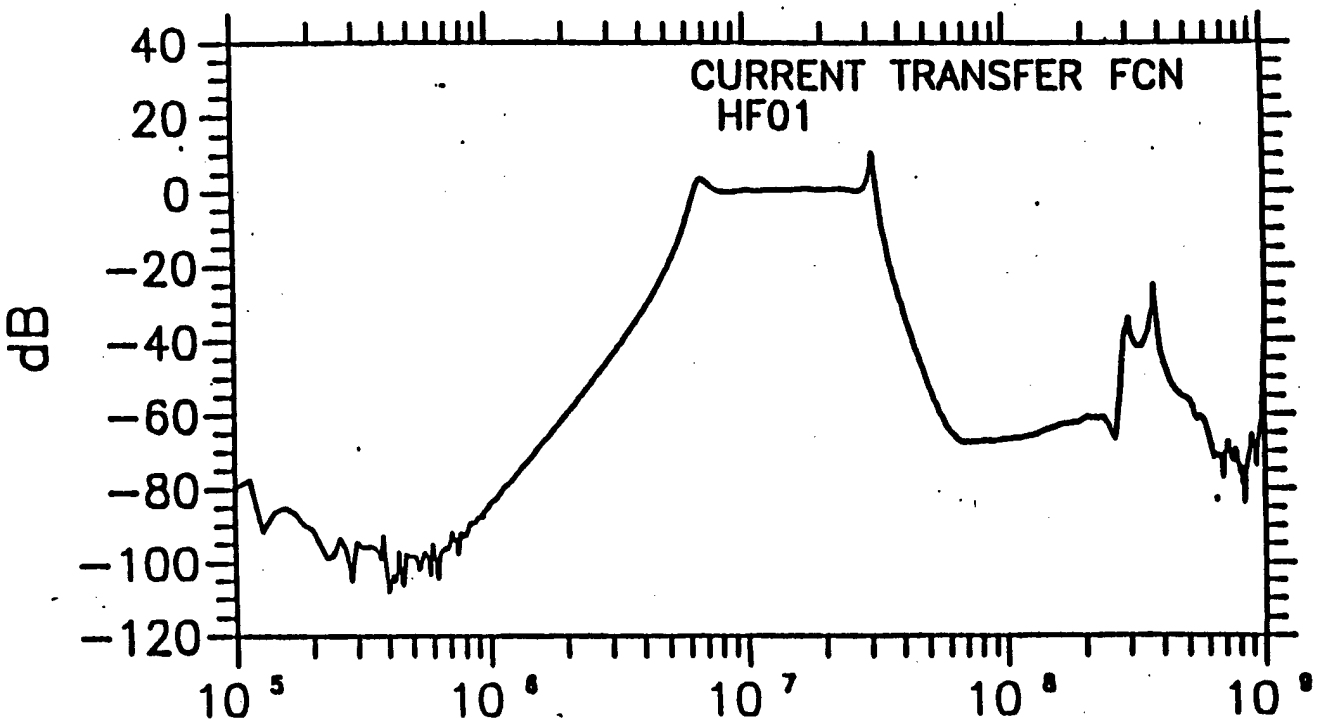
Table 2-2. Specifications of the ESA tested.



Model:	Polyphaser IS-B50LN-CO
Type:	Gas Tube
Turn-on Characteristics:	600 VDC +/- 20% 2.5 ns for 2 kV/ns input

Table 2-1. Specifications of the [redacted] filters tested.

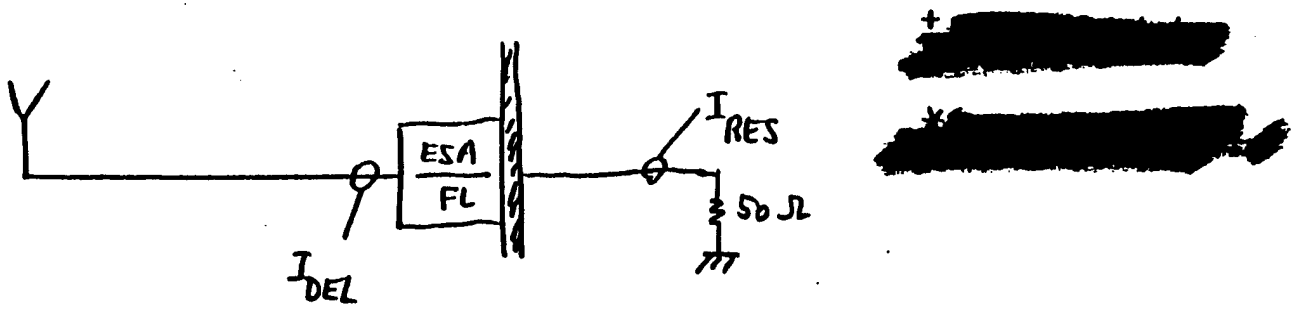




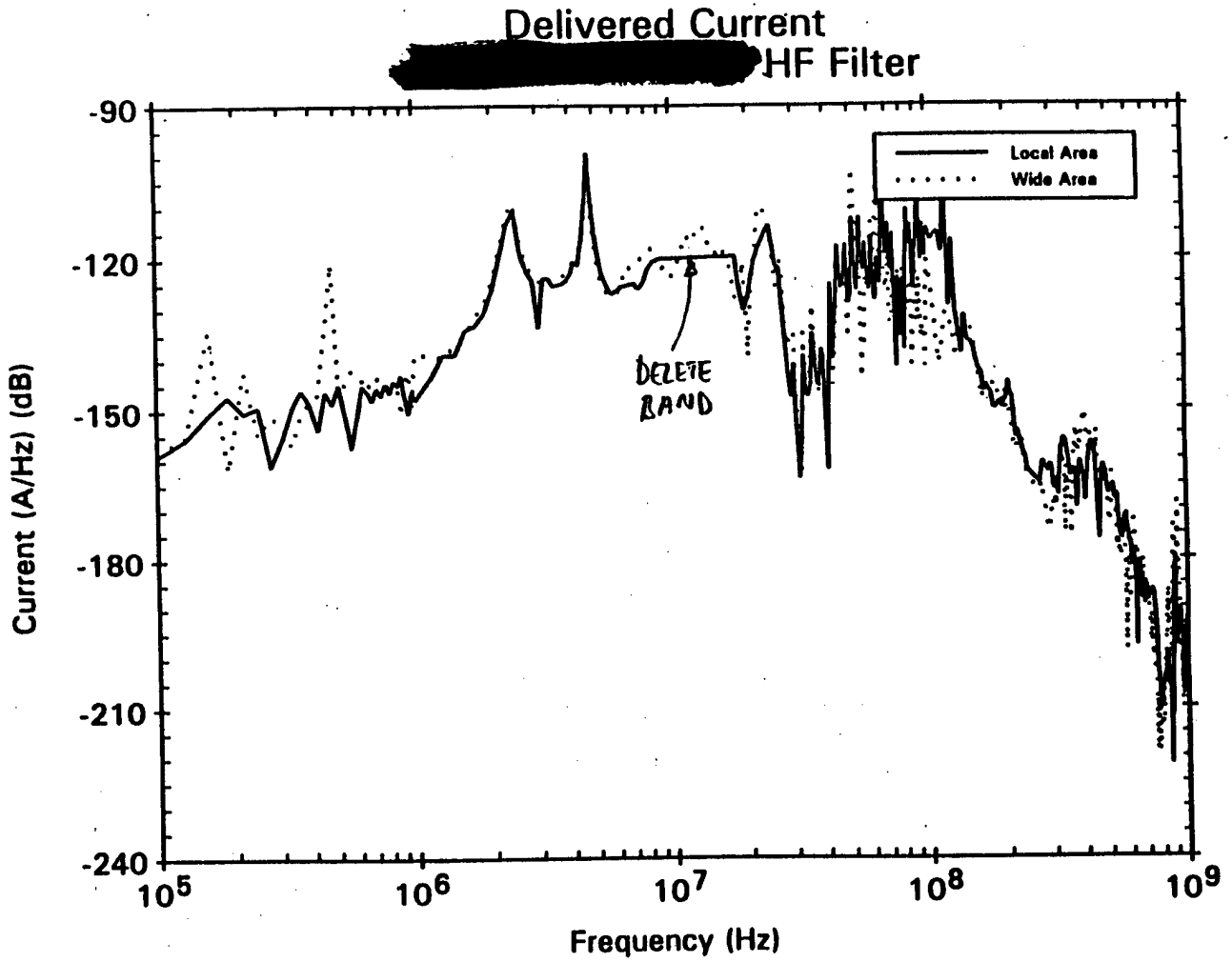
HEMP STRESS ESTIMATES
USING WIDE AREA CWIL vs. LOCAL CWIL WITH SE ANTENNAS

Antenna	Port	ESA + K&L FL:	Peak Curr. I_{DEL} (A)		Peak Curr. I_{RES} (A)	
			Wide Area CWIL	Local CWIL	Wide Area CWIL	Local CWIL
[redacted]			59.2 *	76.2	13.4 *	14.8
			54.7	97.1	2.7	1.8
			35.8	76.3	1.5	3.0
			30.2	45.8	4.5	6.3
			43.3	53.2	2.9	4.5

* The site did not permit illumination testing in the HF band, except for these two measurements.



HEMP STRESS EST. METHOD #3: CALC. I_{SC}^{ANT}, MSD. Z_{ANT} – IN PROGRESS



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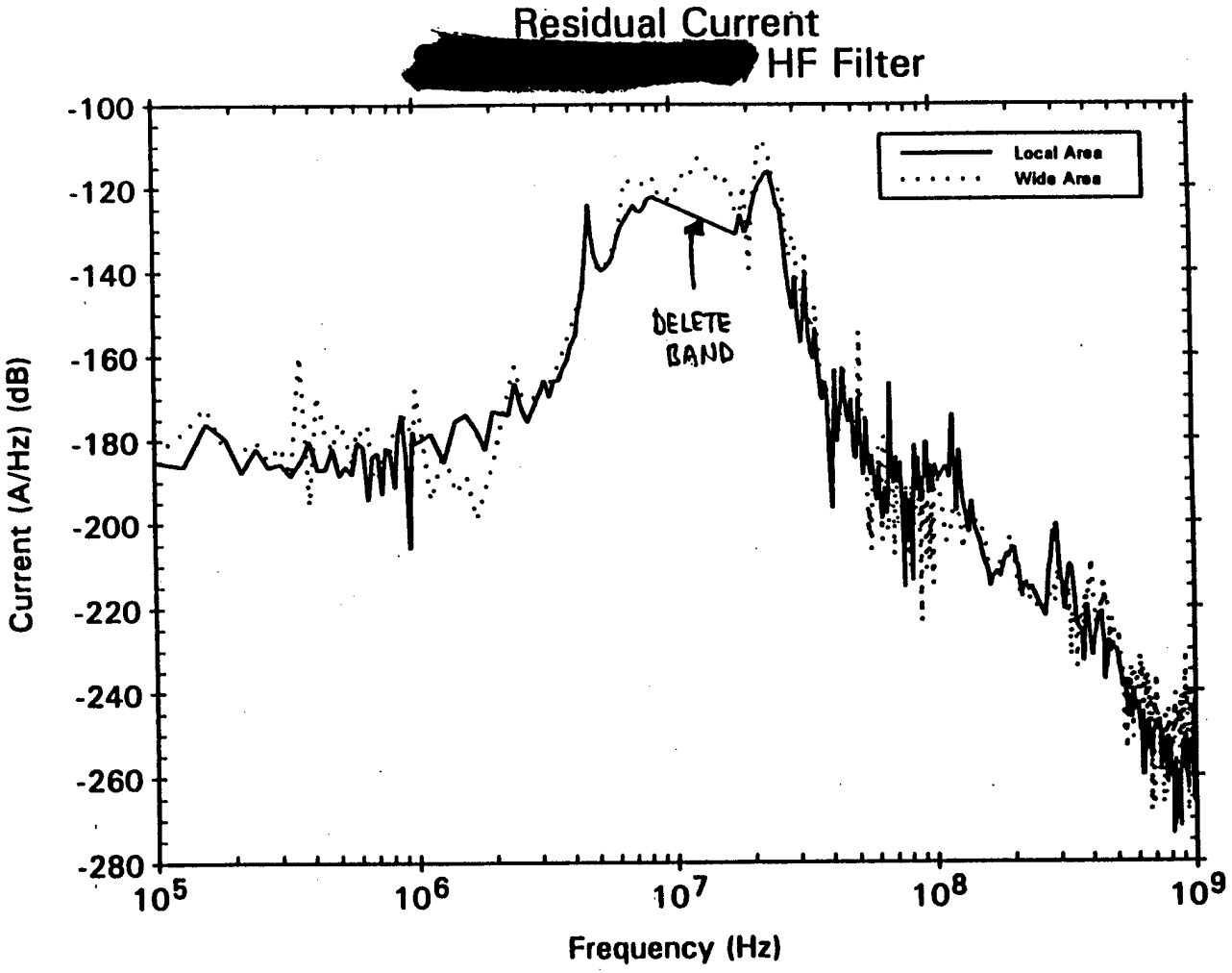

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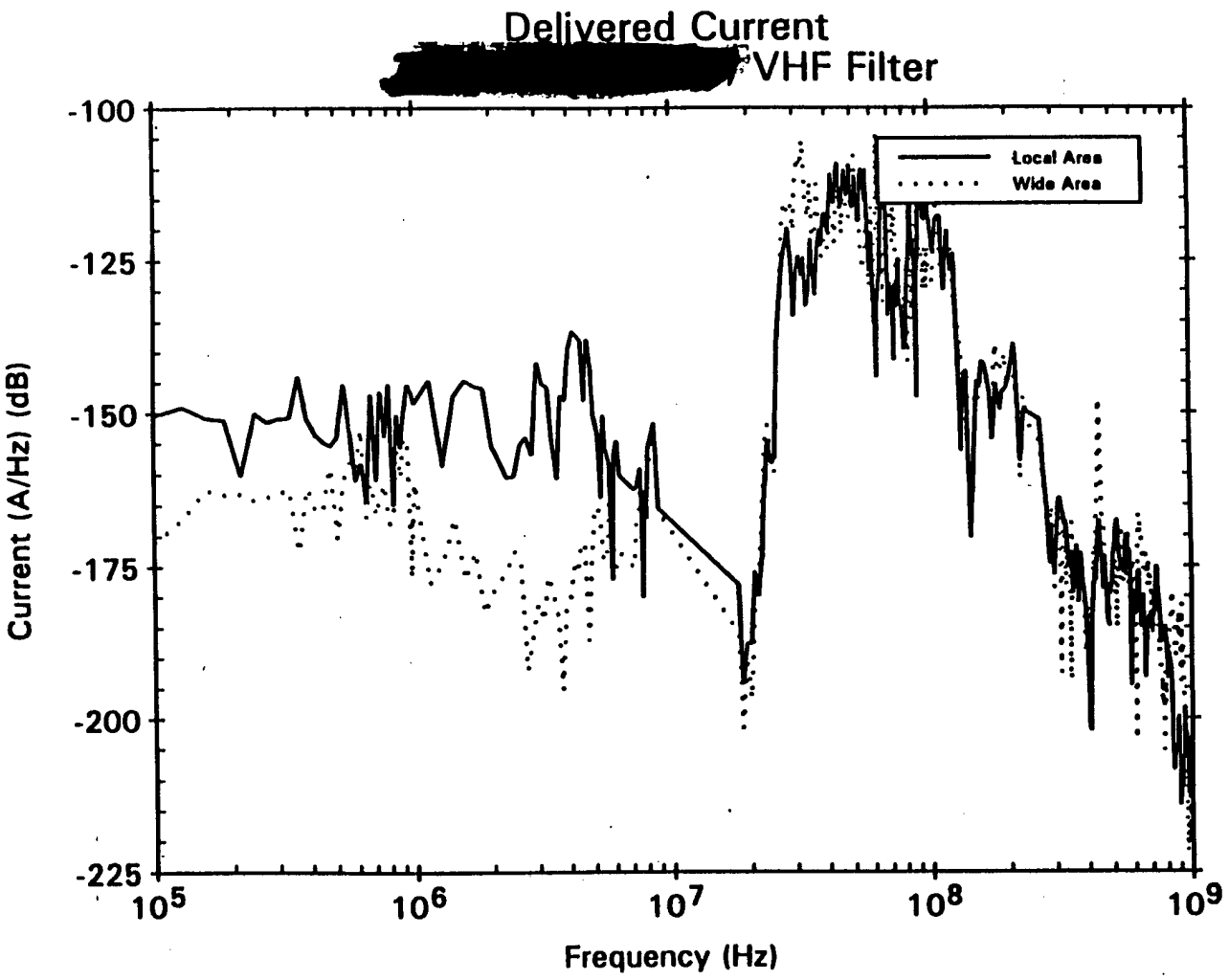

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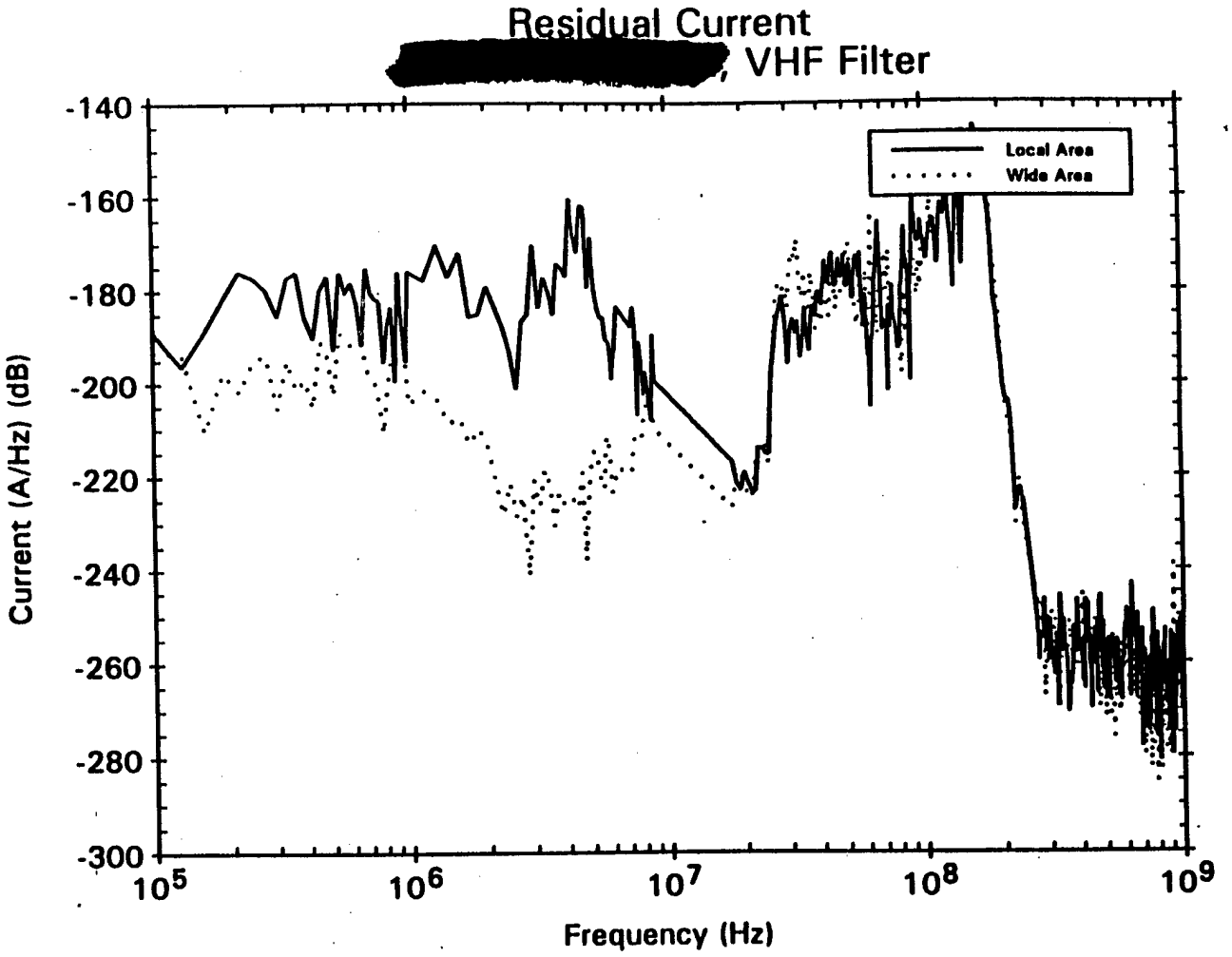

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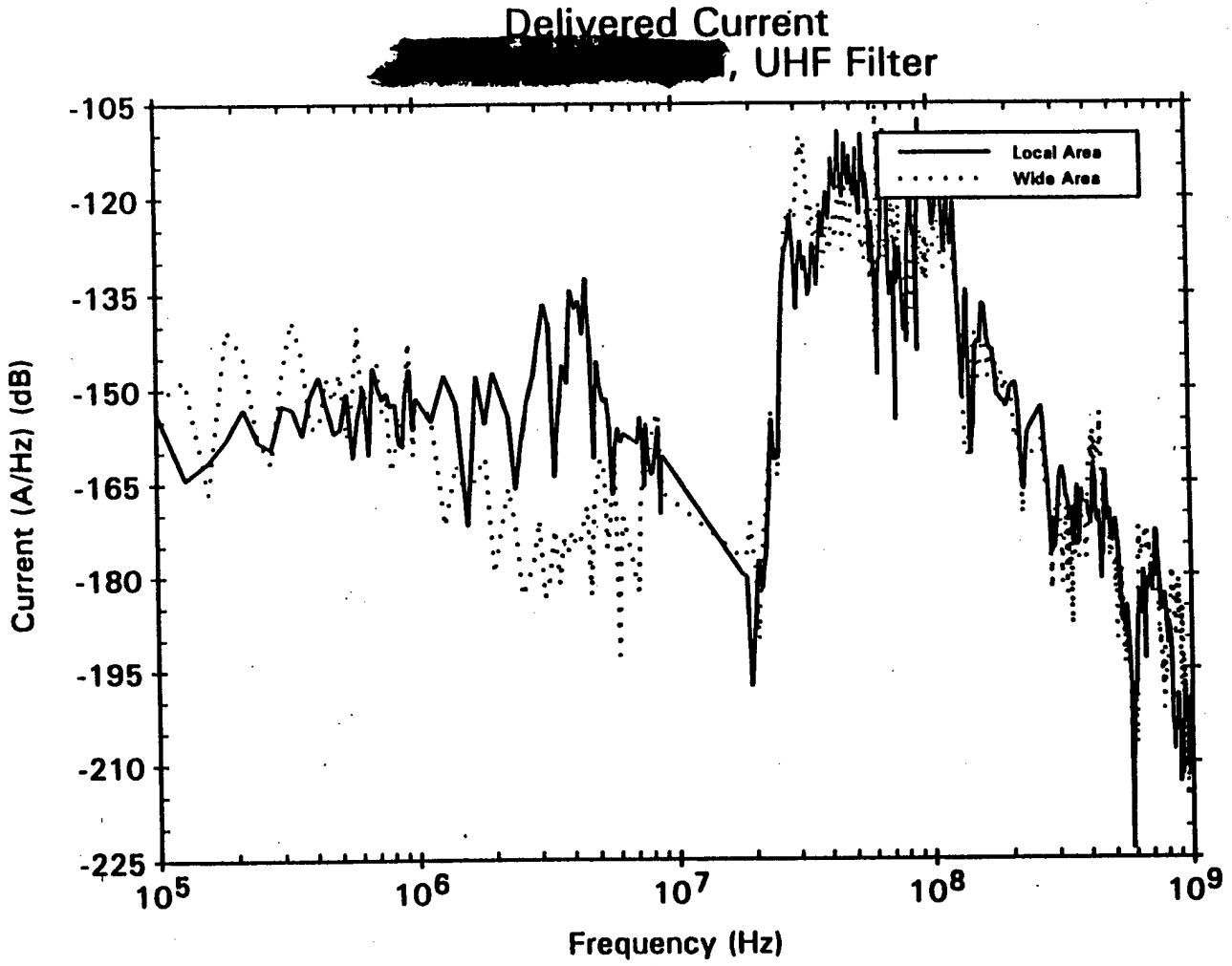

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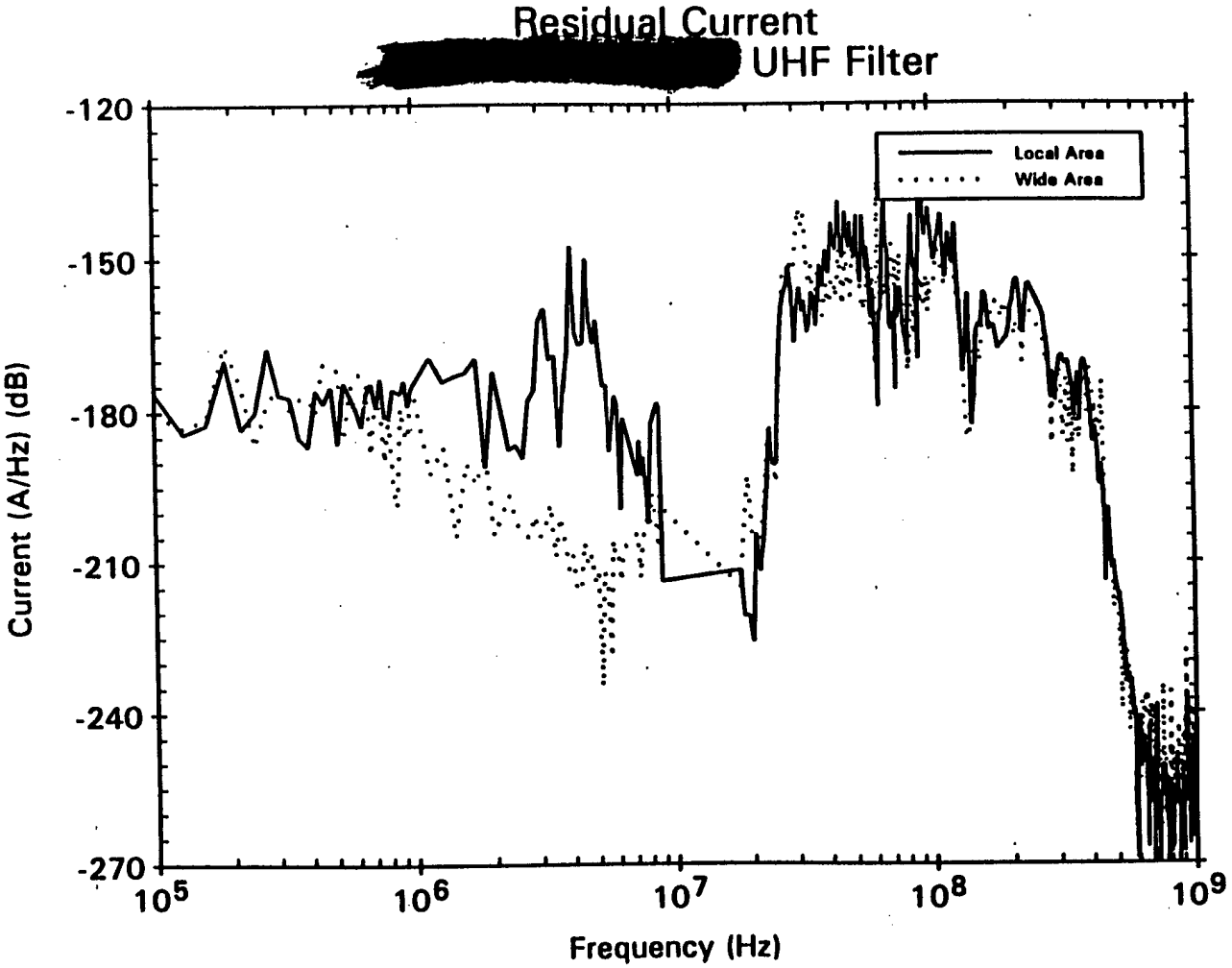

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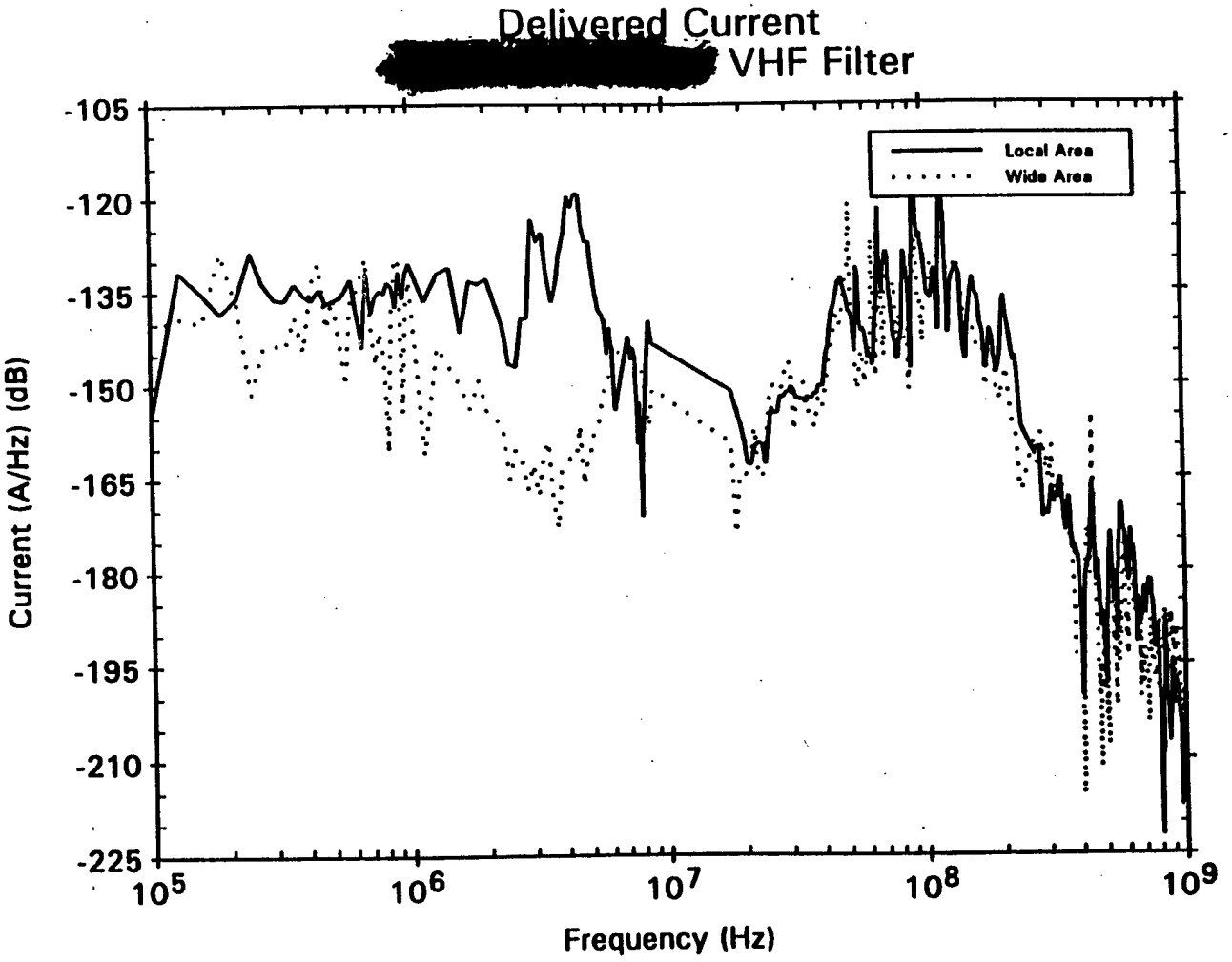

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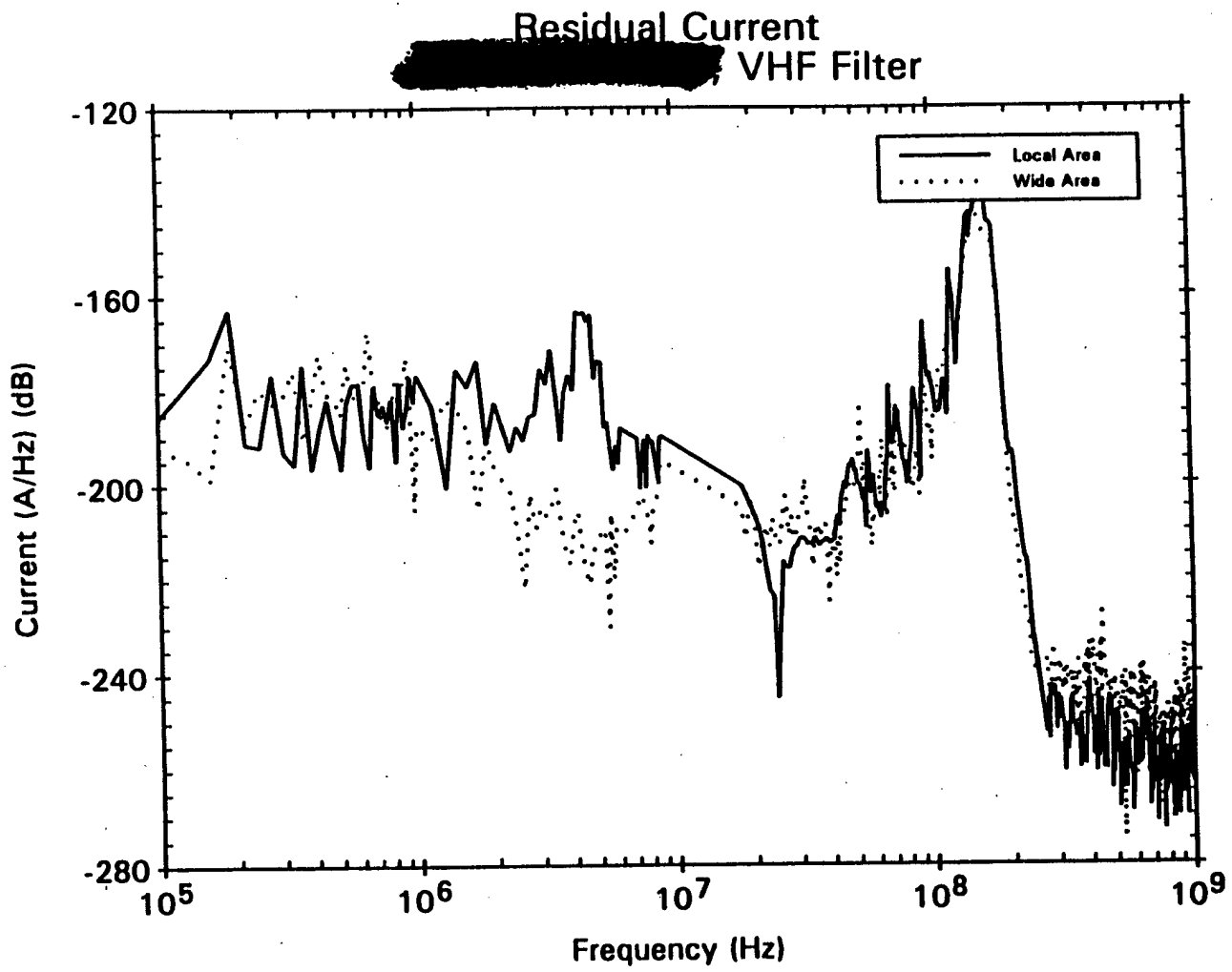

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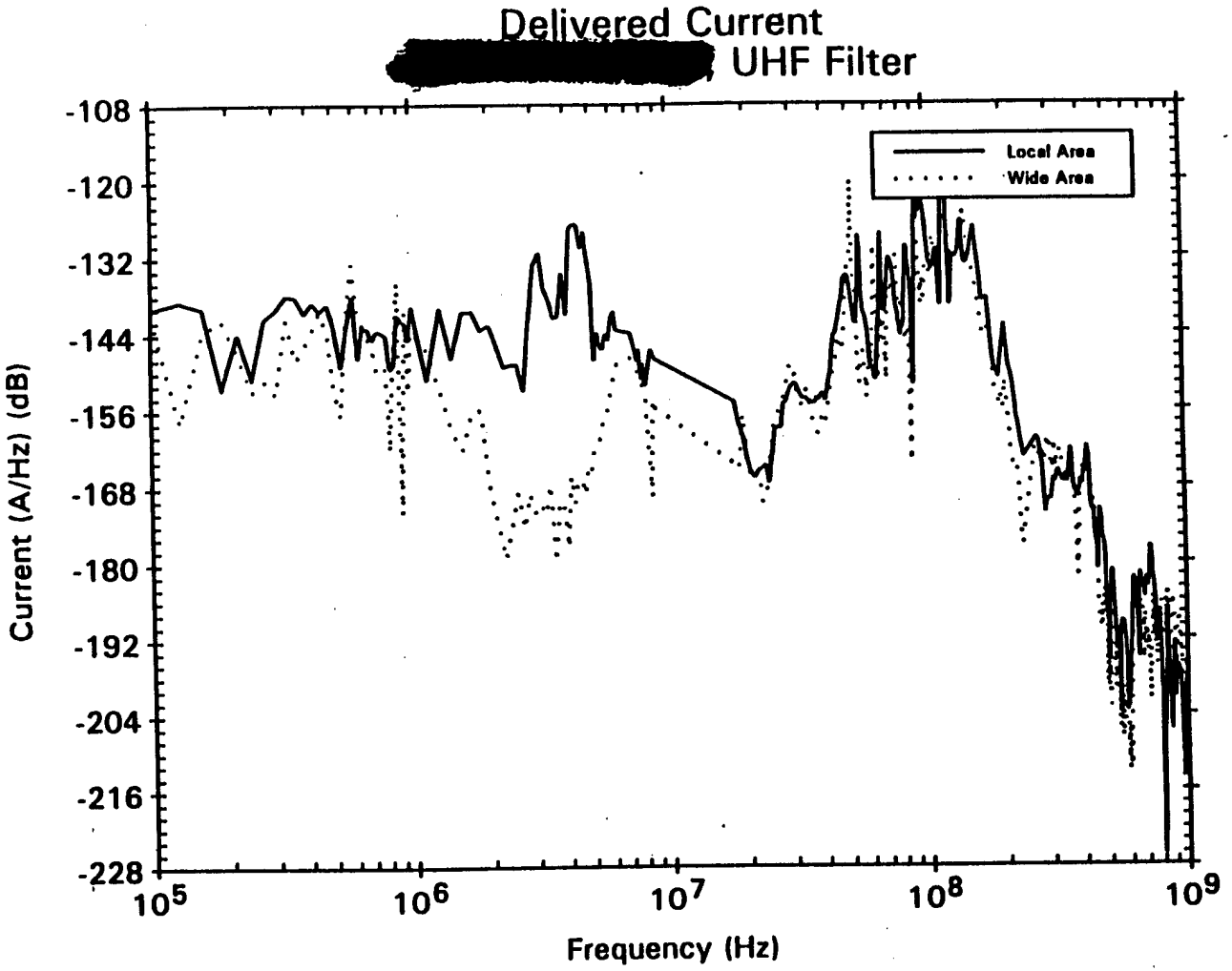

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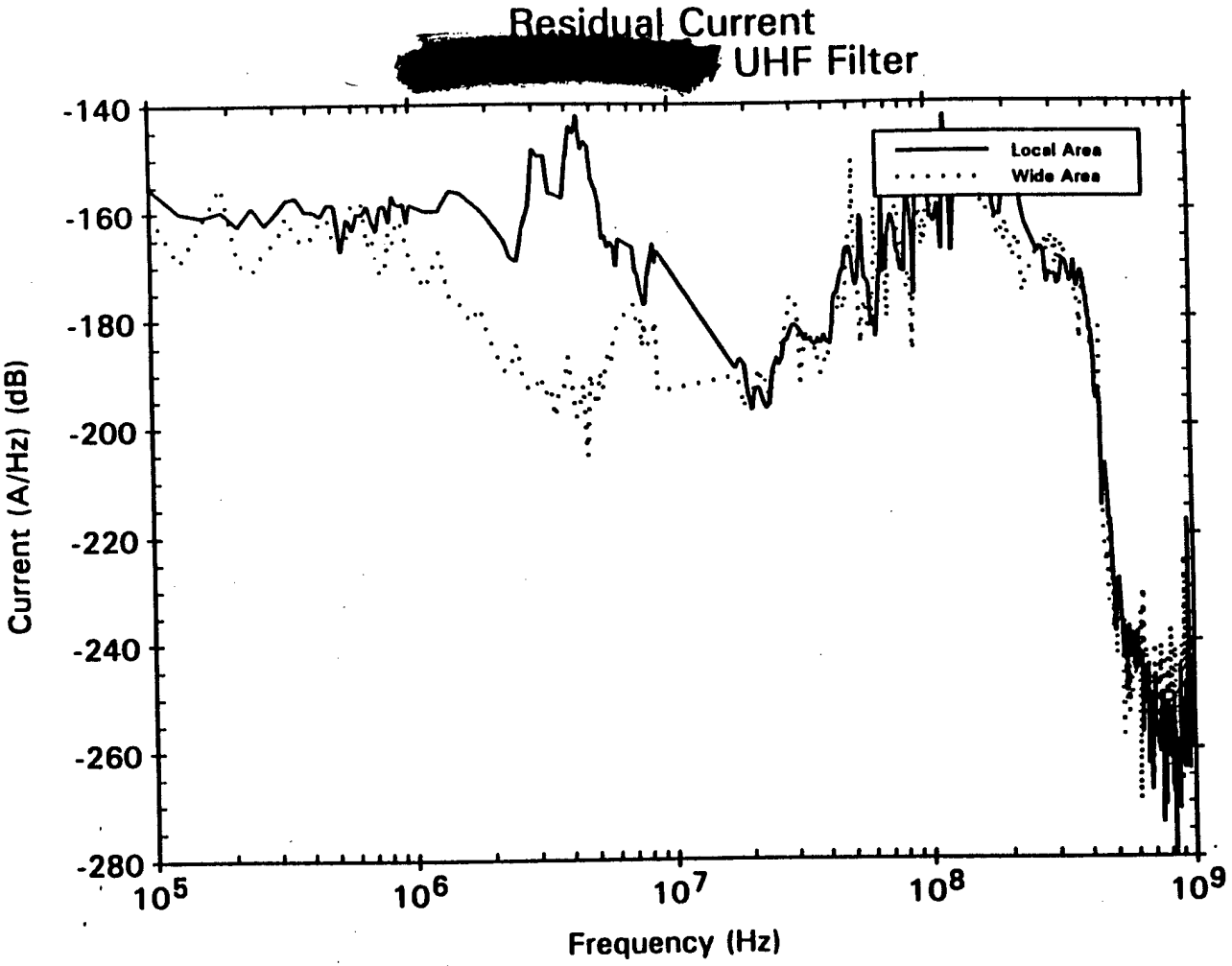

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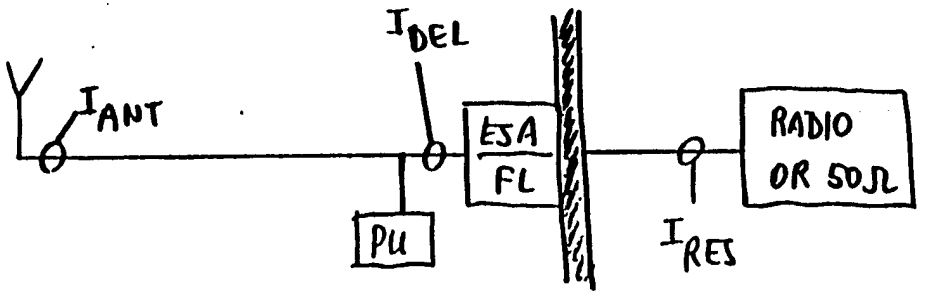
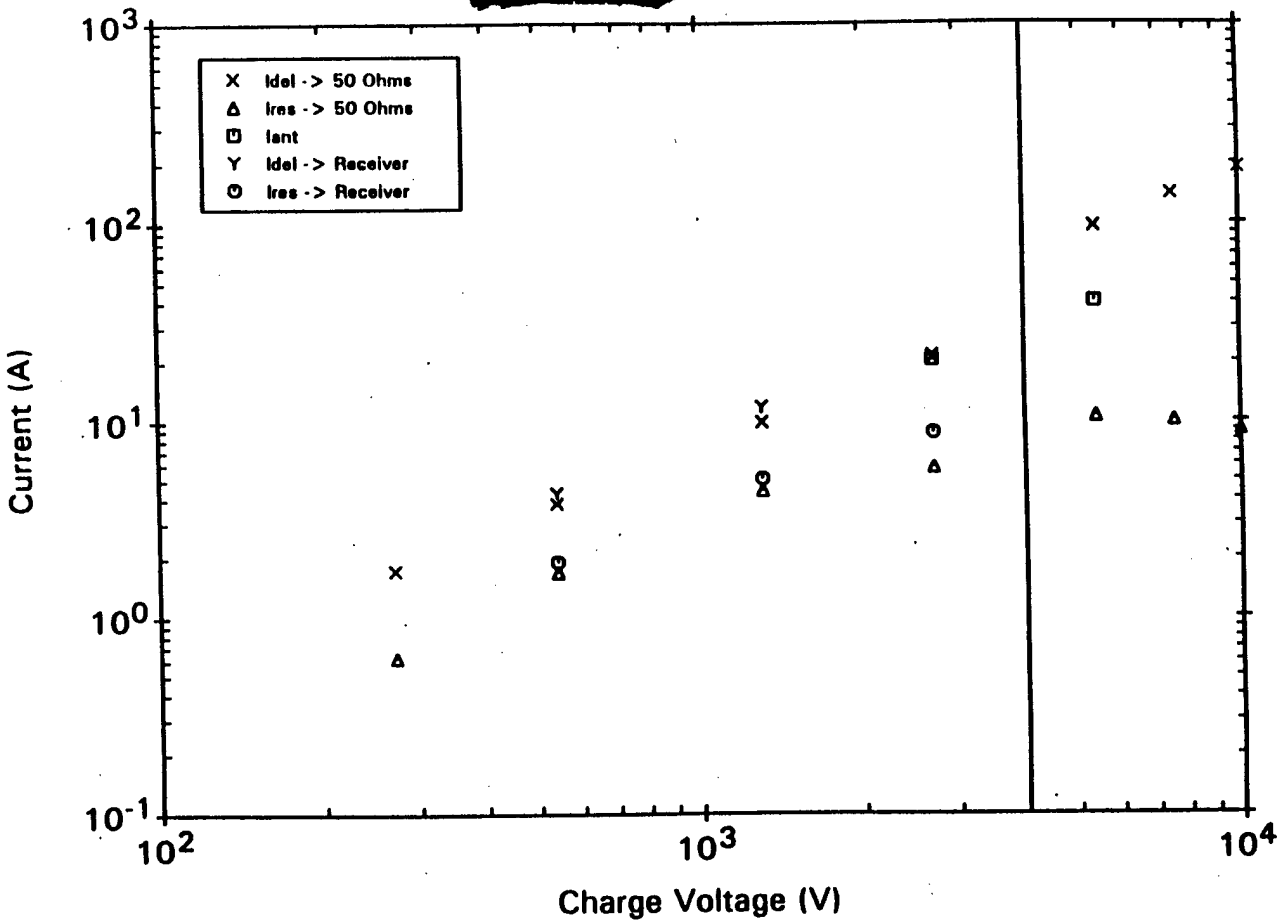
Verification Test of the [redacted] Antenna Penetration

Estimated HEMP Stress: Delivered to the protection device IDEL : 59.2 A
Residual on the protected side IRES : 39.8 A

Pulse current injection with a 5 m long charged line pulser.				
	Ant. line terminated in 50 ohms		Ant. line terminated in the radio	
Pulser Charge Voltage (V):	I_{DEL} (A)	I_{RES} (A)	I_{DEL} (A)	I_{RES} (A)
270	1.7	0.6		
540	3.8	1.7	4.3	1.9
1300	9.9	4.4	11.8	5.1
2700	20.6	5.8	21.3	8.7
5400	95.5	10.5		
7500	139.0	10.0		
10000	188.0	8.9		



Measured Currents vs. Charge Voltage
[redacted] HF Filter



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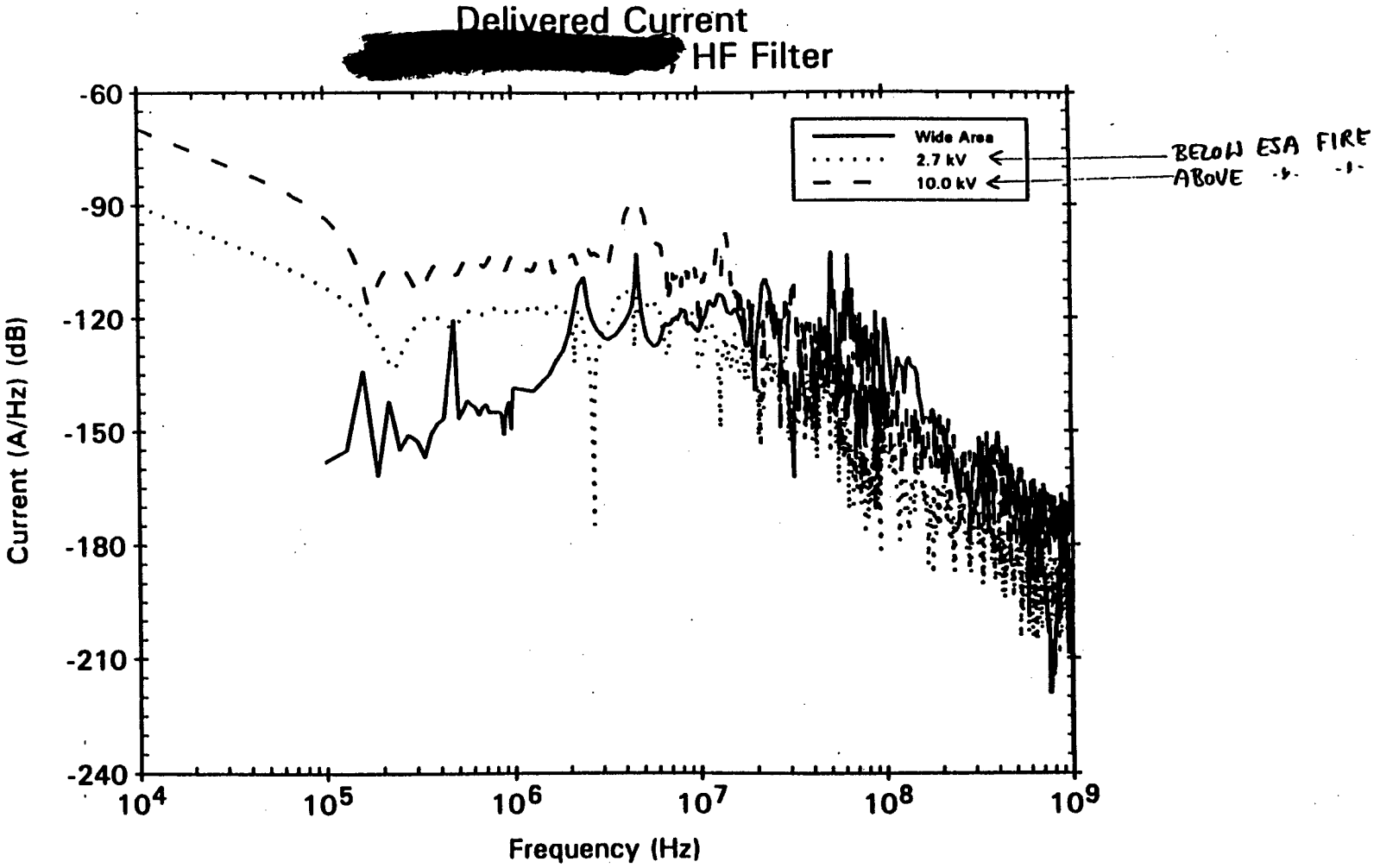

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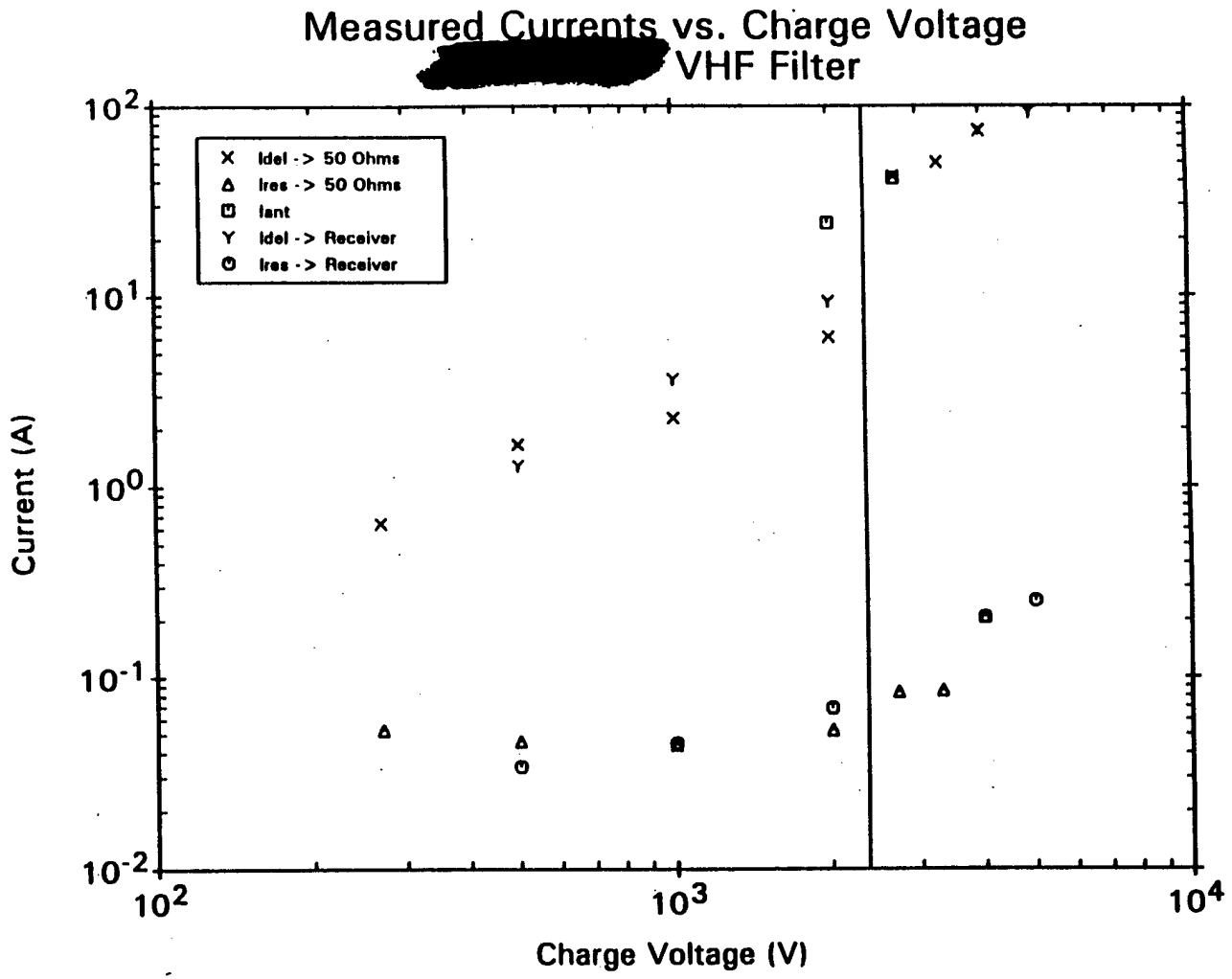

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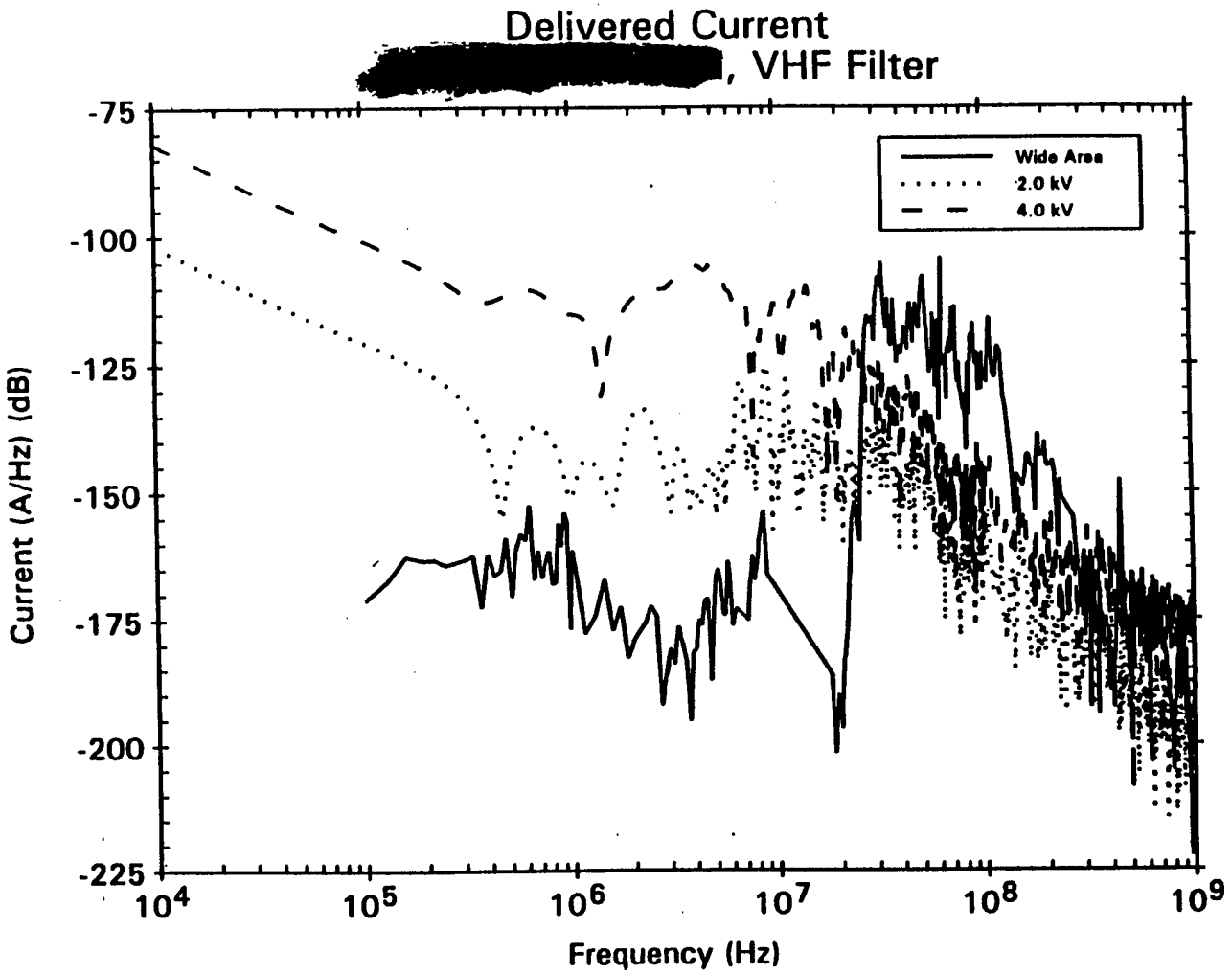

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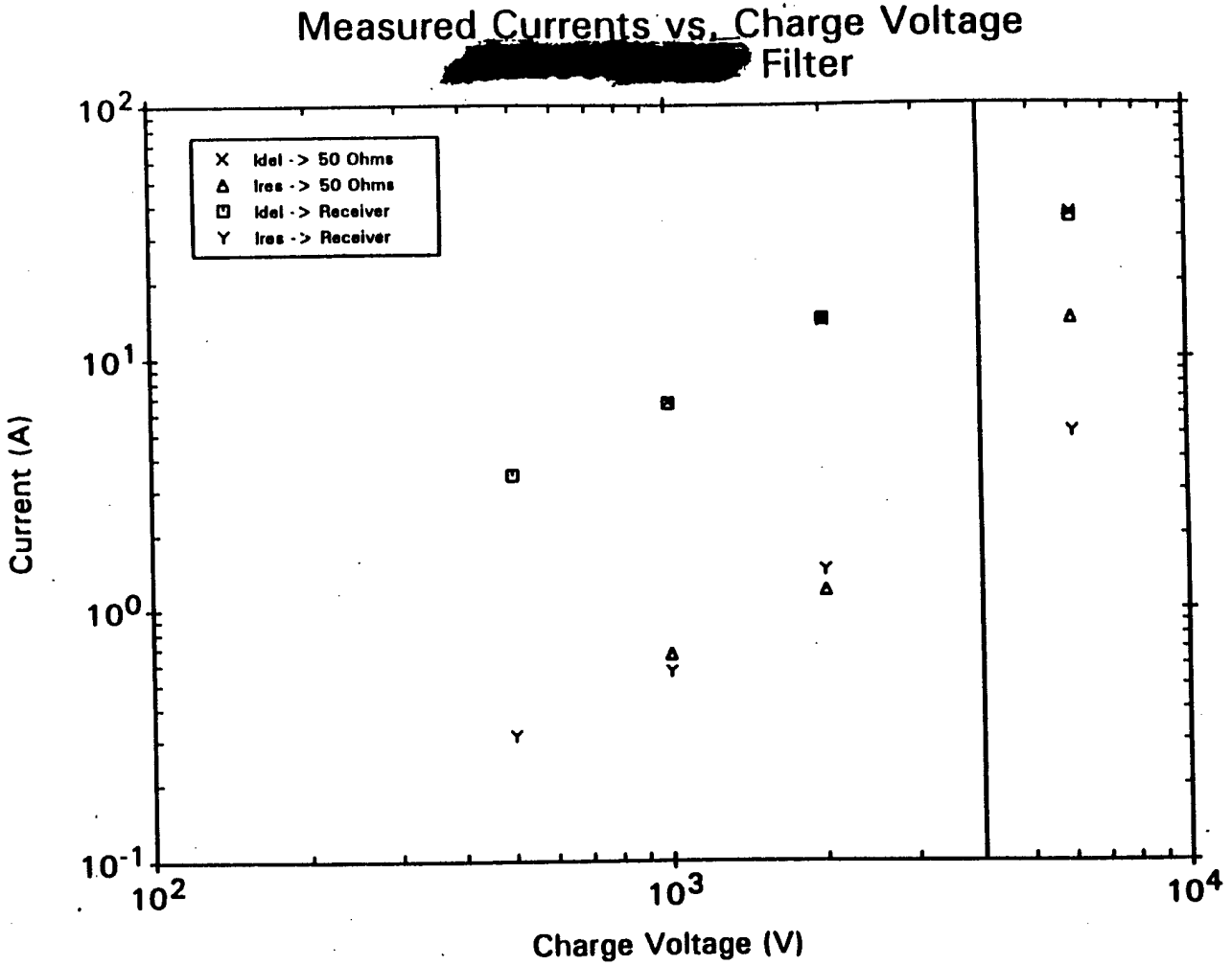

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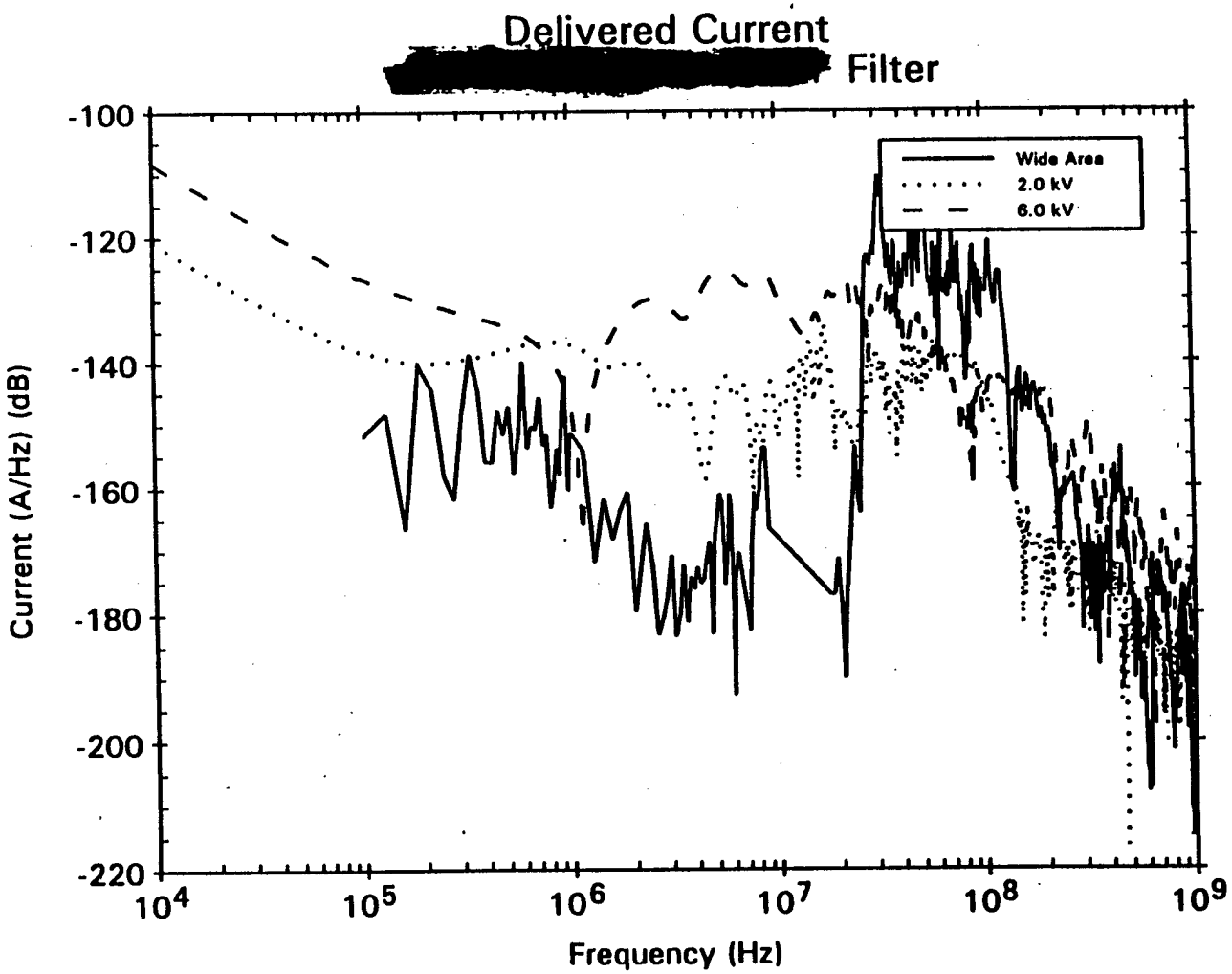

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CONCLUSIONS

1. The proposed verification test procedure was implemented and demonstrated at an operational site.

2. The test coverage provided by the charged line pulser was adequate to test the HF, VHF, and UHF antenna lines.

3. HEMP stresses can be adequately estimated with local CW illumination using the SE transmit antennas.

4. The verification test configuration (antenna leg in parallel with the pulser) did not significantly reduce the test coverage.

5. The [redacted] operated normally even when the pulser TEE was inserted; i.e., the TEE did not interfere with the link.